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REINFORCED PLY-WOOD WEB SPARS

(AIRPLANE SECTION, S. & A. BRANCH)

Prepared by Engineering Division, Air Service
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INDEX.

REINFORCED PLY-WOOD WEB SPARS.

The success of reinforced ply-wood construction in the design of large ribs suggested its application to the construction of large spars such as are used in internally braced construction with thick wing sections.

The following development work was conducted to determine the adaptability of reinforced ply-wood web construction to spars, and also to compare the relative merits of the solid-web and trussed-web types.

Two series of designs and tests were made on each type of construction. The first test emphasized the necessity of certain design features, and the necessity of securing good gluing. The second series of designs incorporated the results of our experience with the first series of designs, and is thought to provide an excellent basis of comparison between the solid-web and trussed-web construction.

FIRST SERIES OF TESTS.

Type A—$\frac{3}{16}$-inch ply-wood truss web reinforced.

Type B—$\frac{1}{8}$-inch ply-wood truss web reinforced.

Type C—$\frac{3}{16}$-inch solid ply-wood web unreinforced.

Type D—$\frac{1}{8}$-inch solid ply-wood web unreinforced.

Type E—$\frac{3}{32}$-inch solid ply-wood web reinforced with vertical stiffener strips.

SECOND SERIES OF TESTS.

Type A—$\frac{3}{32}$-inch solid ply-wood web reinforced with vertical stiffener strips. (See fig. 2.)

Type B—$\frac{3}{16}$-inch ply-wood truss web reinforced. (See fig. 1.)

The spars were supported at the ends and loaded with concentrated loads at the third points. The method of testing is shown clearly in figures 3 and 4.

Tables 1 and 2 are the test results of the first and second series of designs, respectively.

DISCUSSION OF FIRST SERIES OF TESTS.

The gluing on the first series of spars tested was unsatisfactory, and failure occurred in the gluing surfaces before the strength of the spars was developed. The spars were restrained laterally at the ends, quarter points, and center. The spars lacked lateral rigidity even when restrained as noted.

DISCUSSION OF SECOND SERIES OF TESTS.

The gluing on the second series of spars tested was excellent, and no failures could be attributed to faulty gluing. The webs of the solid-web type started to buckle when approximately 40 per cent of the load causing failure was applied. This buckling tendency was most pronounced midway between the load and the support. The end stiffening detail of the spars was found to be inadequate, as there was not sufficient provision made for transmitting the end shear to the supports. The spars were restrained laterally at the ends, quarter points, and center in three cases, and in the fourth case the lateral guides at the quarter points were removed. There was no tendency whatever of any of the spars tested to buckle laterally, and the removal of the lateral supports at the quarter points had no appreciable effect on the strength of the spars.

TABLE 1.—*Results of tests on reinforced ply-wood web spars (series 1).*

Type.	Weight.	Length.	Deflection per total load.[1]									Per cent designed load at failure.	Nature of failure.
			1,120	1,680	2,240	2,800	3,360	3,920	4,480	5,040	5,600		
	Lbs. oz.	*Ft. in.*											
A....	19 21	15 0	0.55	0.96	1.28	....	....	....	....	....	....	50	Failure in glue.
A....	20 0	15 0	.56	.86	....	....	....	....	....	....	....	40	Do.
B....	20 12	15 0	.60	....	....	....	....	....	....	....	....	30	Do.
C....	29 14	15 1	.42	.64	.84	1.06	1.26	1.46	1.64	....	....	90	Do.
C....	28 6	15 1	.50	.76	1.04	1.30	1.54	1.80	....	....	....	80	Do.
D....	25 4	15 1	.46	.70	.92	1.11	1.34	1.56	....	....	....	80	Do.
E....	23 12	15 1½	.44	.67	.86	1.08	....	....	....	....	....	60	Failure in lateral buckling.
E....	23 0	15 1½	.52	.82	1.06	1.22	1.30	....	....	....	....	70	Do.

[1] No deflection recorded at load causing failure.

TABLE 2.—*Results of tests on reinforced ply-wood truss spars (series 2).*

Type.	Weight.	Length.	Deflection per total load.[1]													Per cent designed load at failure.	Nature of failure
			1,100	1,650	2,200	2,750	3,025	3,300	3,573	3,850	4,125	4,400	4,675	4,950	5,225		
	Lbs. oz.	*Ft. in.*															
A....	25 0	15 1½	0.44	0.64	0.86	1.08	1.20	1.32	1.42	1.55	1.67	1.70	1.83	1.96	2.10	100	Bending failure in chord.
A....	24 8	15 8	.36	.61	.83	1.05	1.18	1.27	1.38	1.49	1.65	1.80	......	......	......	85	Do.
B....	23 14	15 4	.53	.81	1.09	1.31	([2])	1.50	......	......	......	......	......	......	......	65	Tension diagonal failed.
B....	22 14	15 4	([3])	([3])	([3])	([3])	1.75	......	......	......	......	......	......	......	......	60	Tension chord failed.

[1] The deflections were measured at the center of the spars.
[2] Omitted.
[3] Inaccurate records.

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DISCUSSION OF FIRST SERIES OF DESIGNS.

The construction of the first series of spars tested was similar to the construction of the second series tested, the chief difference being that the flanges of the first series of spars were solid rectangular sections.

The design data is as follows:

All spars designed for two concentrated loads of 2,800 pounds at third points.

Modulus of rupture of spruce, 10,000 pounds per square inch.

Yield point in compression, 6,000 pounds per square inch.

Coefficient fixity web members:

2.50 in plane of truss.

1.75 normal to plane of truss.

Casin glue used.

Gluing strength taken as 1,000 pounds per square inch.

All members designed for 40 per cent reversal of stress in reversed flight.

The flanges of all spars were designed to resist the entire bending moment, and the web was designed to carry the shear. The allowable tensile and compressive strengths of ply wood when the applied load makes various angles with the direction of the grain were determined by charts constructed by the Haskelite Research Laboratory, which are reproduced in this report in figure 5. The shearing strength of ply wood was determined in accordance with the results of a series of tests made by the Forest Products Laboratory, which are incorporated in a report entitled "Shear strength of ply-wood webs," Project L-225-1. The principle that solid ply-wood webs are best adapted to resist shear when the direction of the face plies is at 45° with the axis of the beam was proven by tests recorded in the report cited. Therefore, the solid-web spars were designed in accordance with this principle.

Due to the defective gluing in the first series of spars, it is impossible to state the true strength of the designs tested. The tests indicated, however, that all spars tested were laterally unstable, and that further development work should take into consideration the widening of the flanges. The necessity of careful gluing was also evident.

The Pratt type of truss was used because the diagonal web members would be in tension in direct flight. The design of these members was limited by the reversed flight condition in which 40 per cent of the direct flight stresses were assumed, and of the opposite character. In the design of the web members direct stresses only were considered, and the effect of the eccentric application of the direct stress due to the lack of symmetry of the web section was ignored.

DISCUSSION OF SECOND SERIES OF DESIGNS.

The construction of the second series of spars tested is shown in figures 1 and 2.

The design data was the same as for the original spars with the following exceptions:

Coefficient of fixity of web members:

2.00 in plane of truss.

1.25 normal to plane of truss.

Loading, two concentrated loads of 2.750 pounds at the third points.

TRUSSED-WEB SPARS. (SEE FIG. 1.)

To secure lateral rigidity, the flanges were widened and the depth kept the same. In order to have sufficient gluing surface for the web members, the flanges were routed so that the sectional area of the flanges closely approximated the area of the original flanges.

The compression web members were designed by the method of secondary deflections to compensate for the eccentric application of the web stresses. This method of analysis had given excellent results in the design of a number of 15-foot reinforced ply-wood truss ribs and checked up closely in static test. This method of analysis is considered fully in McCook Field report, appendix to serial No. 1483.

SOLID-WEB SPARS.

The solid-web spars shown in figure 2 were designed as before. The flanges were designed to resist the entire bending moment and are exactly the same as for the trussed-web type. The web was made of $\frac{3}{32}$-inch spruce-popular ply wood reinforced with vertical stiffeners. The average vertical shearing stress at the designed load is much less than the shearing strength of the ply wood, but the consideration of stiffness is extremely important. This question of stiffness is taken up later in this report and a method of computing the size and spacing of web stiffeners is given. At the points of concentrated loading the stiffeners were designed to distribute the shearing stresses to the web, and at the points of support the stiffeners were designed to transmit the end shear.

RECOMMENDATIONS.

As the result of the test, it is strongly recommended that solid-web construction should be used in preference to the trussed-web construction. The solid-web type is more advantageous as regards strength-weight ratio, rigidity, ease of production, and economy of material.

It is recommended that the design should be made in accordance with the following principles:

(*a*) Relation between depth and width. To secure lateral rigidity the ratio between the depth of the spar and the width of the flanges should not exceed five.

(*b*) The flanges should be designed to resist the entire bending moment. The area of the flange sections required at any point is equal to the bending moment at the point in question divided by the product of the distance between centers of gravity of flanges and the allowable fiber stress in tension or compression. The yield point in compression should be used for the compression flange, and in general no reduction for column action will be necessary. The direct stress should be divided between the flanges in proportion to their respective sectional areas.

The depth of the flanges should provide sufficient gluing surface for the web. The depth required is found by computing the increase in longitudinal shear per inch near the point of maximum shear. There must be sufficient gluing surface to develop this stress. Experiment has proven that the strength of the gluing surface between two layers of wood is dependent upon the angle between the directions of the grain of the adjacent layers. When the directions of the grain in the adjacent layers are parallel the gluing strength is a maximum, and when the directions are

perpendicular the gluing strength is a minimum. For the former case the longitudinal shearing strength of the wood rather than the strength of the gluing surface will be the limiting condition, while in the latter case the strength of the gluing surface will govern. Also in the case of the solid-web spars in which the plies make an angle of 45° with the direction of the grain, the gluing strength will limit the design. It is recommended that the intensity of longitudinal shearing stress between the web and the flanges should not exceed 250 pounds per square inch. Further work should be conducted to determine the allowable values of the gluing strength when the direction of the grain of adjacent wood fibers varies from zero degrees to 90°.

To secure an economical flange design, it is advisable to rout the section, thus securing the necessary width and gluing surface with the minimum sectional area.

(c) The web should be designed to resist the shear. The average vertical shearing stresses are greatest near the supports. If the assumption that the web resists only the external shear is adhered to, the state of stress at any point in a vertical section of the web would be the same as that existing at the neutral axis of a solid beam. At any point in the web the planes of principal stress make an angle of 45° with the axis of the beam, and the intensities of the compressive and tensile stresses on these planes would each be equal to the intensity of the shearing stress on a vertical plane. Thin veneer (not ply wood) or laminated wood is not suitable to resist tensile stresses perpendicular to the direction of the grain. Ply wood, however, is very well adapted for this purpose, and it is one of the purposes of this report to discuss the qualities of ply wood which make it suitable for the webs of spars.

To secure maximum efficiency the ply wood should have the following qualities:

1. Maximum strength-weight ratio.
2. Tensile resistances equal when the applied load is normal and parallel to direction of the grain of the face plies.
3. Column bending resistance equal when the applied load is normal and parallel to direction of the grain of the face plies.
4. Maximum resistance to vertical shearing forces.

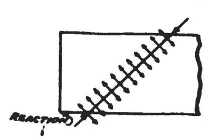
The Forest Products Laboratory conducted a series of important tests on the shearing strength of ply-wood webs, and recommended that the grain of the face plies should be at 45° with the axis of the spar. The variation in the maximum shearing stresses is shown in figure 6 for 3-ply ply wood of birch consisting of $\frac{1}{12}$-inch faces and $\frac{1}{8}$-inch core when the external shear is at various angles with the direction of the grain of the face plies. In our analysis it is assumed that the face plies are at 45° with the axis of the spar.

The column-bending, tensile, and shearing strengths of ply wood increase almost in direct proportion with the density of the material. It is not advisable, however, to use a dense material like birch for all plies, because the reduced total thickness of ply wood necessary is accompanied by a reduction in stiffness. The stiffness of the web is proportional to the unsupported distance between flanges divided by the thickness of the web. Birch, however, makes an excellent material for the faces because of its high strength and resistance to abrasion. It is advantageous to use a dense material like birch for the faces with a less dense material like poplar, spruce, or basswood for the core.

The tensile strength and column bending strength of ply wood when the applied load is parallel to the direction of the face plies decreases as the thickness of the core is increased, while the corresponding strengths perpendicular to the direction of the face plies increase. To secure uniform strength when using a core of poplar, spruce, or basswood in connection with dense face plies of birch, the core should be thickened. It is recommended that the core should constitute between 60 and 75 per cent of the total thickness of ply wood when using three plies. If more than three plies are used, the denser material should be thinner than the less dense core. The use of a wood such as poplar, spruce, or basswood of comparatively low density for the core makes it possible to secure a relatively thick ply wood for a given strength-weight ratio, and thus secure stiffness.

The tensile strength and column bending strength of ply wood when the applied load is parallel to the direction of the face plies decreases as the number of plies is increased, while the corresponding strengths perpendicular to the direction of the grain of the face plies increase. To secure uniform strength, the greatest number of plies possible should be used.

To illustrate the necessity of designing the web to resist column action, a portion of the web near the supports will be isolated and the forces acting on the section will be considered. (See sketch.) The section isolated is restrained laterally along its entire length by the tension in the web, and is subjected to compression along its axis. The ply wood must have sufficient strength to resist this load. It is interesting to note in this connection that both solid-web spars tested developed secondary failures due to this action. The average intensity of the shearing stress at failure, which also equals the intensity of the normal stresses on the principal planes, was 1,520 pounds per square inch, whereas the maximum allowable column bending modulus was 1,600 pounds per square inch, according to the Forest Products Laboratory report. The column bending moduli are equal to $P/A+My/I$ at failure, and may be taken as the criteria for column strength equivalent to the moduli of rupture for bending strength.



SUMMARY OF CHOICE OF WEB.

1. Use ply wood to secure uniform strength as nearly as possible.
2. Use as many plies as is consistent with economy of production.
3. Use face plies of high density with a core of relatively less density. Birch is recommended for the face plies in connection with a core of poplar, spruce, or basswood. When using three plies the core should constitute from 65 to 70 per cent of the total thickness of ply wood. The lower value represents the proportion necessary to secure about uniform tensile strength and the higher value represents the proportion necessary to secure uniform column bending strength. When using more than three plies, the relation between the total thickness of the lighter

wood to the denser wood should be slightly in excess of the inverse relation between the respective densities.

4. If the core and faces are the same kind of wood, the core should constitute 50 to 65 per cent of the total thickness of the ply wood when three plies are used. The lower limit will about equalize the tensile strengths, and the higher value will about equalize the column bending strengths when the applied load is parallel or normal to the direction of the grain of the face plies.

When the ply wood is proportioned as recommended, it will be unnecessary to design for column bending resistance and tensile resistance on diagonal planes at the points of maximum shear, because the vertical shearing stresses will limit the design.

A formula is derived below to determine the maximum allowable shearing stresses for plywood when the applied load makes an angle of 45° with the direction of the grain of the plies. The formula is based on the test results of 3-ply birch ply wood conducted by the Forest Products Laboratory. The shearing resistance of various woods are assumed to vary as their densities. This formula is approximate, but is the best indication of the shearing strength that can be obtained in the absence of experimental data.

$$f_s = \frac{a}{0.67} \times 5{,}000 \times \frac{c}{100} + \frac{b}{0.67} \times 5{,}000 \, \frac{(1-c)}{100}$$

Let a=density of core.

b=density of faces.

c=per cent or lighter wood of total thickness of ply wood.

$(1-c)$=per cent faces or denser material of total thickness of ply wood.

0.67=density of birch.

The following values of the allowable shearing stresses have been determined in accordance with the formula stated:

Number of plies.	Material.		Density.		Per cent total thickness.		f_s pounds per square inch.
	Face plies.	Core.	Face plies.	Core.	Face plies.	Core.	
3	Cherry	Basswood	0.56	0.42	40	60	3,550
3	do	Poplar	.56	.50	40	60	3,910
3	do	Spruce	.56	.42	40	60	3,550
3	do	Spanish cedar.	.56	.41	40	60	3,505
3	do	Mahogany	.56	.50	40	60	3,910
3	Birch or hard maple.	Basswood	.67	.42	40	60	3,880
3	do	Poplar	.67	.50	40	60	4,240
3	do	Spruce	.67	.42	40	60	3,880
3	do	Spanish cedar.	.67	.41	40	60	3,835
3	do	Mahogany	.67	.42	40	60	3,880

The spacing of intermediate web stiffeners is indeterminate, but a method of analysis is developed which is a modified form of the analysis upon which the spacing of vertical stirrups in reinforced concrete beams is based.

$$v = \frac{SQ}{I}$$

v=increase in longitudal shear per inch.

S=total external shear.

Q=statical moment of flange about horizontal axis of spar.

The approximations are made that the flanges have equal areas, that the moments of inertia of the flanges about their centers of gravity are negligible, and that the horizontal axis is halfway between the flanges.

$$v = \frac{S \times A \times h/2}{\frac{h^2 A}{2}} = \frac{S}{h}$$

A=area of flange.

h=distance center to center of flanges.

The assumption is made that the vertical stiffeners develop in tension the longitudinal shearing stresses between two adjacent stiffeners.

$$F = \frac{VXd}{2} = \frac{Sd}{2h}$$

F=tensile strength of stiffeners.

$$d = \frac{2\,Fh}{S}$$

d=spacing of stiffeners.

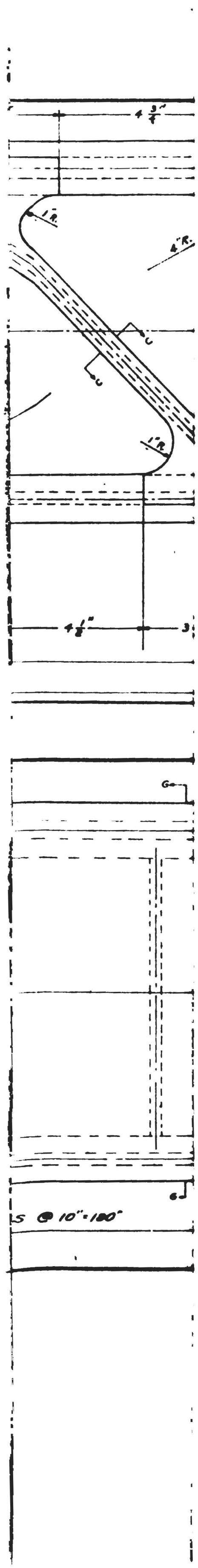
The spacing should not exceed the unsupported distance between flanges. Stiffeners should be used at the point of attachment of the ribs. In general, this condition will limit the spacing, since stiffeners will be required at the ribs and at a point intermediate between ribs.

Intermediate web stiffeners of rectangular section are advised, with the greatest dimension outstanding from the web of the spar. The outstanding dimension should be about ½ inch+1/30 the unsupported distance between flanges. The stiffeners should have a good bearing against the flanges.

At points of heavy load concentration and at the supports the stiffeners should be designed to transmit the load to the web in the first case, and from the web to the supports in the latter case. In order to secure sufficient bearing area at the supports and at points of heavy load concentrations, it is recommended that the routing of the flanges should be omitted at these points, and that portal stiffeners should be used. These stiffeners may be made in two sections as shown. All stiffeners with unsymmetrical sections and loaded eccentrically should be designed by the method of secondary deflections. The application and use of this method is completely covered in McCook Field report, appendix to Serial No. 1489, entitled "Experimental reinforced ply-wood truss ribs."

In the appendix there are several charts which will aid materially in the design of solid web ply-wood spars.

References: Project report L-225-1, Forest Products Laboratory, entitled "Strength tests on ply wood," and "Shear strength of ply-wood webs."


4 3/4"
1"R.
4"R.
1"R.
4 1/2"
S @ 10" = 180"

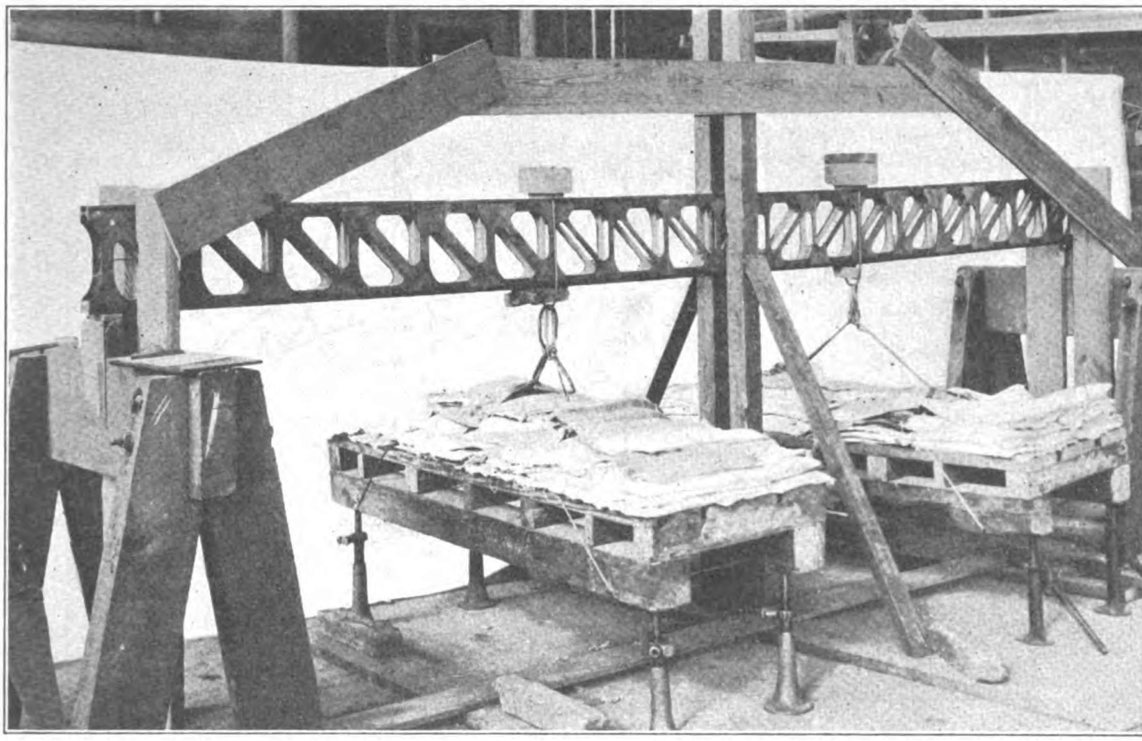


FIG. 3.

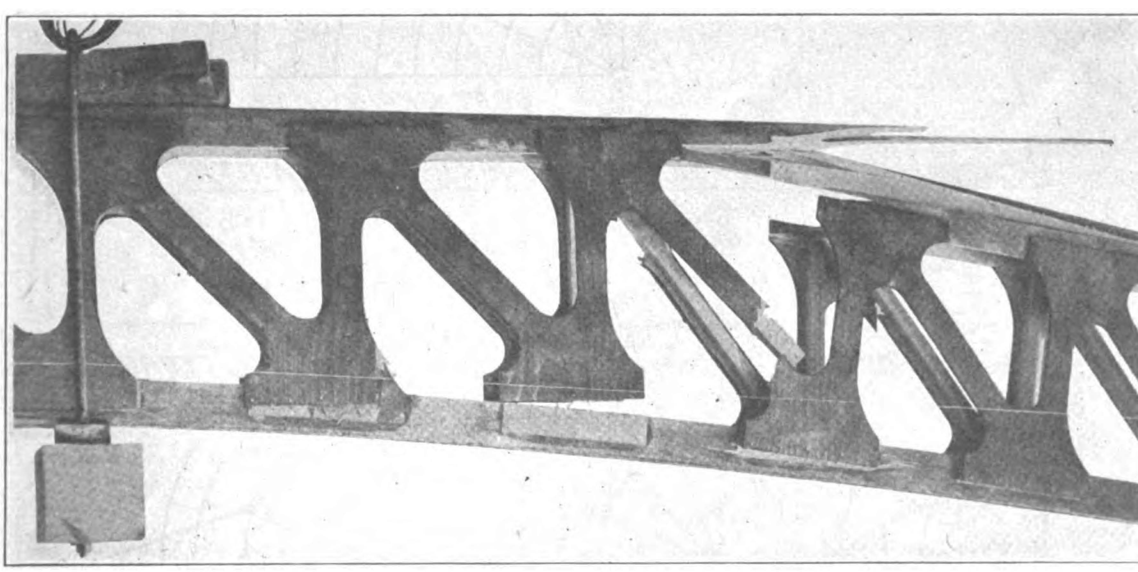
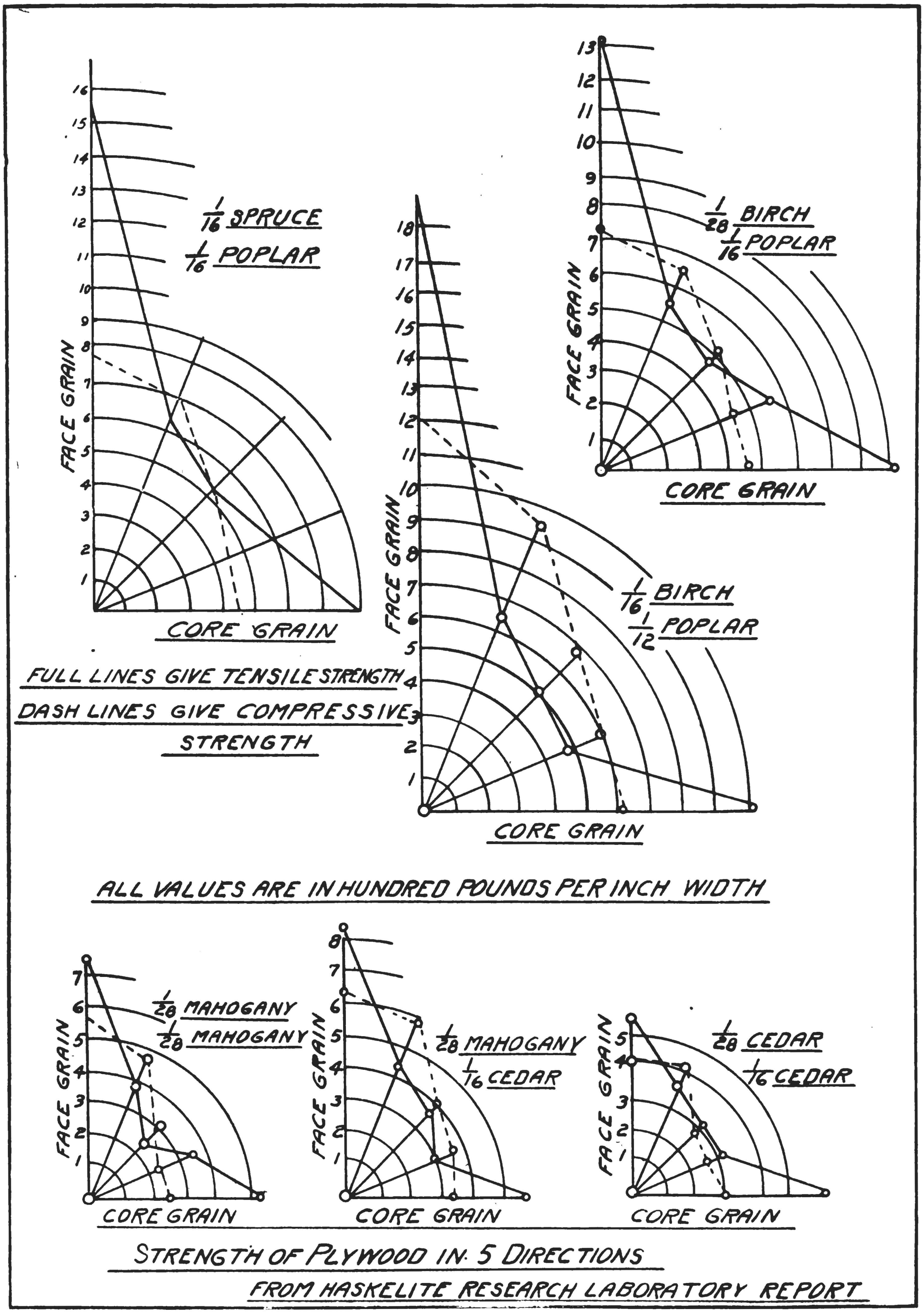
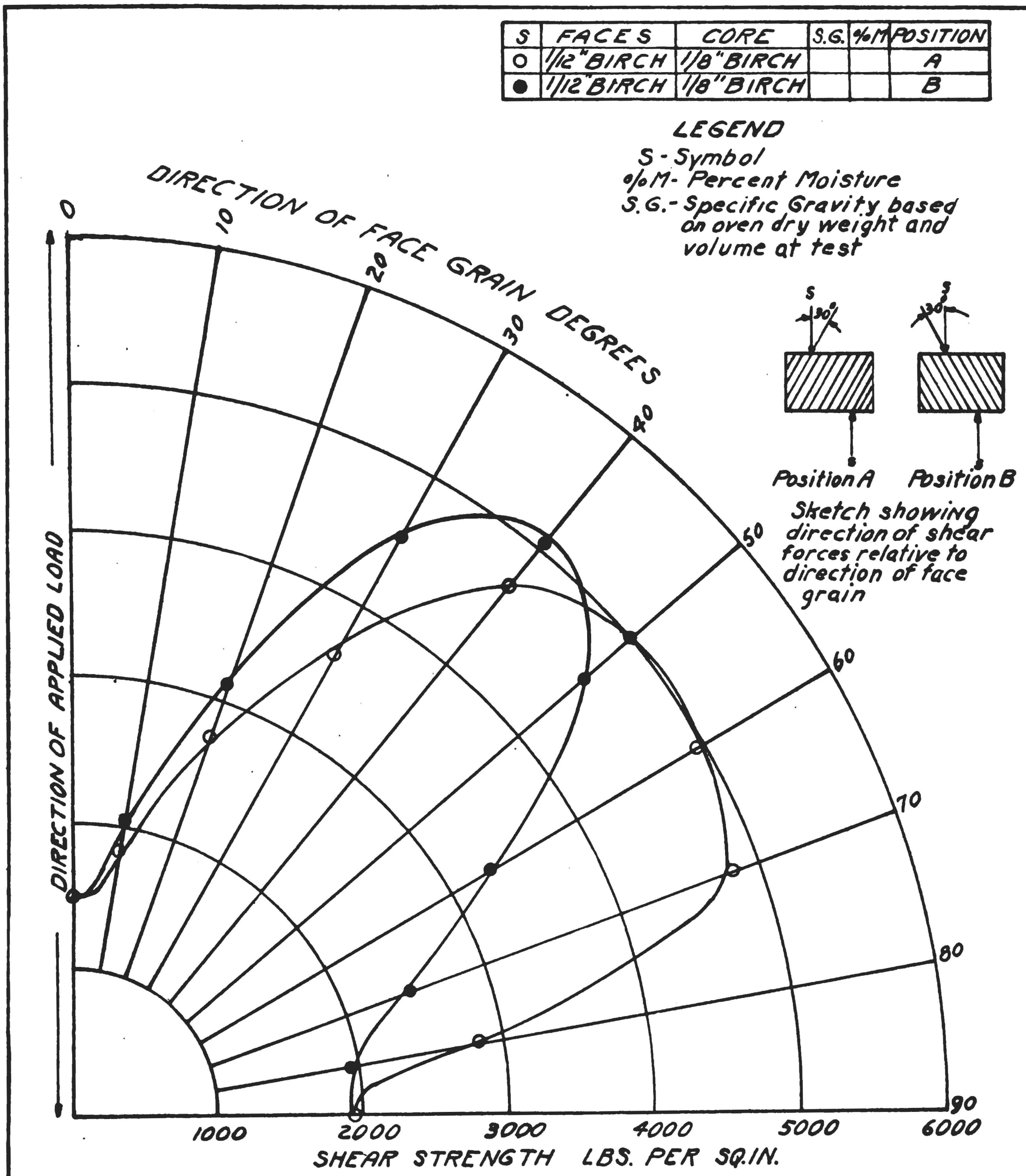


FIG. 4.



1/16 SPRUCE
1/16 POPLAR
FACE GRAIN
CORE GRAIN
FULL LINES GIVE TENSILE STRENGTH
DASH LINES GIVE COMPRESSIVE STRENGTH
1/16 BIRCH
1/12 POPLAR
1/28 BIRCH
1/16 POPLAR
ALL VALUES ARE IN HUNDRED POUNDS PER INCH WIDTH
1/28 MAHOGANY
1/28 MAHOGANY
1/28 MAHOGANY
1/16 CEDAR
1/28 CEDAR
1/16 CEDAR
STRENGTH OF PLYWOOD IN 5 DIRECTIONS
FROM HASKELITE RESEARCH LABORATORY REPORT

FIG. 5.



RELATION BETWEEN

UNIT SHEAR STRENGTH OF 3 PLYWOOD

AND

DIRECTION OF GRAIN

LENGTH OF SHEAR SPECIMENS 3 INCHES

DISTANCE BETWEEN SHEAR FORCES $\frac{1}{4}$ INCH

REPRODUCED FROM FOREST PRODUCTS LABORATORY REPORT

FIG. 6.

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McCOOK FIELD REPORT, SERIAL No. 1739

AIR SERVICE INFORMATION CIRCULAR

(AVIATION)

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INSTRUCTIONS FOR STROMBERG NA-L5 DOUBLE VENTURI INVERTED TYPE AIRPLANE CARBURETOR

(POWER PLANT SECTION)

Prepared by Engineering Division, Air Service
McCook Field, Dayton, Ohio
July 28, 1921

WASHINGTON
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1922

CERTIFICATE: By direction of the Secretary of War, the matter contained herein is published as administrative information and is required for the proper transaction of the public business.

INSTRUCTIONS FOR STROMBERG NA-L5 DOUBLE VENTURI INVERTED TYPE AIRPLANE CARBURETOR.

This carburetor has been especially designed for the Liberty 12 engine with supercharger installation. The float mechanism and general principals of operation are similar to those of previous Stromberg models as described in the Stromberg Airplane Carburetor Manual, but the inverted construction has necessitated changes in the detail of design.

STARTING.

Engines equipped with the inverted carburetor require much more liberal priming than engines equipped with the Zenith carburetor. These carburetors will start most readily with about eight full shots form the Lunkenheimer primer. After priming, with the throttle full closed, turn propeller over at least three cylinders. The throttle lever should then be set about 1 inch from the full closed position and the engine cranked. If these instructions are followed, the inverted carburetors give no more trouble in starting than the standard Zenith carburetors.

OPERATION.

The economical operation of this carburetor depends upon an intelligent use of the mixture control, commonly known as the altitude control. At an altitude of 5,000 feet and a cruising engine speed of 1,500 revolutions per minute the saving effected by the proper use of this control will amount to an increase of 15 per cent in the radius of action. The mixture control is of the suction bleed type with the two carburetors of one motor balanced with each other, and is effective to any altitude obtainable.

To set the control proceed as follows:

Slowly move the control lever in the "Lean" direction until the engine speed drops or the engine action becomes irregular. A slow movement of the lever is absolutely necessary on account of the appreciable length of time taken by the float chamber pressures to balance after a change of conditions. The changing conditions may cause temporary slight variations of engine speed and these should not be confused with a permanent loss of speed. When the position of lowered speed of the engine is reached, immediately bring the lever back in a "Rich" direction 2 or 3 inches and when the engine has resumed normal speed and regular action, again move the control lever in the "Lean" direction, this time to a point just short of the point of irregular action. (For more detailed information on the use of the mixture control see Air Service Information Circular, No. 257, Vol. III.)

This will be the proper control position for minimum fuel consumption at the altitude and throttle position at which the setting is made.

ADJUSTMENTS.

The metering orifices (see fig. 1) are located on either side of the float chamber at "A." A No. 42 orifice is the correct size for the Liberty 12 engine. In case of removal of these metering orifices care should be taken that the edges of the restriction in the center of the orifices are not marred and that the metering orifices do not drop into the float chamber. A brass wire or tapered stick of wood will be found useful to guide the nozzle while it is being withdrawn and to prevent it from falling into the float chamber. The mixture control should be used to regulate the mixture for varying temperature conditions. In cold weather the mixture control lever should be kept in the full rich position at ground level. In warm weather it may be set to give a leaner ground adjustment.

The idling mixture adjustments are located at "B" (see fig. 1). These operate on an air bleed and screwing them right hand inward gives less air and a richer mixture while the left-hand turn gives a leaner mixture. The idle adjusting needle should always be somewhat off the seat when the gasoline is first turned on, as otherwise the fuel may syphon over the top of the idling tube and escape into the intake manifold. Another adjustment of the utmost importance for smooth running at low speed is the throttle stop adjustment "X" (see fig. 1). It is very important that the minimum throttle openings be accurately synchronized or made equal on the front and rear carburetors, so that all cylinders are kept warm and firing properly while idling. To avoid the effect of possible lost motion in the throttle rod connections, the stop screws "X" should be adjusted in the minimum throttle opening position on both front and rear carburetors. Proper synchronization of the throttle stops will make it possible to use a considerably leaner idling mixture adjustment, as referred to in the preceding paragraph, and considerably reduce the "loading up" in gliding to a landing.

MIXTURE CONTROL COMMONLY KNOWN AS ALTITUDE CONTROL.

The mixture control valve is a separate unit and only one valve is used for two carburetors. The suction connection is made of fixed size and is taken from the small tubes "E" extending down to the throat of the small venturi. The outside air connection is regulated by the mixture control valve, the air being taken from the air scoop on top of the carburetor, or the supercharger air duct, when the latter is fitted. The air entering through the mixture control valve serves to break the partial vacuum on the float chamber caused by the suction bleed and a regulation of this air gives a consequent regulation of the pressure on the float chamber. The tubing connections should be one-half inch O. D. copper tubing with rubber hose connections. On a loop or sideslip to the left, this tubing may fill with gasoline, but it will promptly clear itself as the ship is righted. See figure 2 for proper installation and position of this valve.

FLOAT LEVEL AND DRAINS.

The float level should be $1\frac{3}{8}$ inches to $1\frac{1}{2}$ inches below the top finished faces of the carburetor main body. The carburetor has been designed so that any overflow from flooding will escape over the edge of the accelerating well

cups "C" and out through the drain connection "D." When superchargers are used, the lines from the drain connections must be fitted with shut-off valves which must be closed while the engine is running, but opened after every flight to drain out any gasoline which has collected in the carburetor. The fuel pressure should not exceed 5 pounds per square inch. To guard absolutely against the possibility of flooding the manifolds, a regular practice should be followed of shutting down the engine by shutting off the fuel, also of turning the fuel on only just before starting the engine. When the airplane is left standing out of doors for any considerable time a cover should be left over the air scoops.

STRAINER.

The strainer is located under plug "Y." The chamber may be drained of most of the accumulated dirt by removal of the drain plugs "Z." Care should be taken that this strainer space is drained and cleaned at regular intervals.

ASSEMBLY.

If for any reason the carburetors have been removed from the engine and disassembled, the following items are of primary importance in the reassembly and installation:

(1) All joints must have good gaskets and be absolutely tight. Joints to be especially watched are: Between parting surfaces of carburetor (paper), between carburetor wells and carburetor body (fiber), and between carburetor and intake header (paper). The condition of the packing and rings around the large venturi should also be checked.

(2) Before installing the carburetors on the engine the butterfly throttles of the individual carburetors should be checked; that is, the gear sectors should have no backlash, they should be securely fastened on the throttle shafts as also should the butterflys themselves, and the two butterflys should close exactly together. This latter is of the greatest importance for smooth running below 800 revolutions per minute.

(3) The throttles of the different carburetors should be synchronized as explained under "Adjustments."

(4) Great care should be taken that the mixture control connections are securely made and that the air lines are not clogged with bits of rubber or foreign matter.

For further information in regard to these carburetors address The Engineering Division, Air Service, Dayton, Ohio.

INSTRUCTIONS FOR CHANGING TO NEW TYPE IDLING ADJUSTMENTS STROMBERG INVERTED DOUBLE VENTURI MODEL NA-L5 CARBURETORS.

The following instructions are applicable to Stromberg inverted NA-L5 carburetors with the following serial numbers only:

SERIAL NUMBER.

1344788	1419776	1419789	1419804
1344790	1419777	1419790	1419805
1419765	1419778	1419791	1419806
1419766	1419779	1419794	1419807
1419767	1419780	1419795	1419808
1419768	1419781	1419796	1419809
1419769	1419782	1419797	1419810
1419770	1419783	1419798	1419811
1419771	1419784	1419799	1419812
1419772	1419785	1419800	1419813
1419773	1419786	1419801	1419814
1419774	1419787	1419802	1419815
1419775	1419788	1419803	1419816

All other carburetors were shipped from the factory with the later type of idling adjustment installed. If for any reason the serial number has been lost or become obliterated, a comparison of the carburetor with the accompanying sketches will show what type of adjustment it has.

The essential difference between the two types is that in the old type the air was drawn from the atmosphere while in the new type the air is drawn from inside of the carburetor body (see fig. 3).

After securing the new type adjustment proceed as follows:

Remove the cover from the carburetor by taking out four fillister head screws, three bolts, and idle adjustment sleeves "B." (This last will require a hexagonal socket wrench five-eighths inch across, flat). Taking care not to mar finished faces, counterbore the carburetor cover from the bottom side, nine-sixteenths of an inch diameter to a depth of one-eighth inch in the two holes for the idle adjustments. Then with a small chisel (holding the carburetor cover in the lap or on a wood bench so as not to warp it) chisel out an opening one-eighth of an inch square or larger from these counterbores to the respective air spaces of the carburetor. Then replace cover, taking care to locate gaskets properly and put in new idle adjustments with about one-thirty-second of an inch fiber washer underneath.

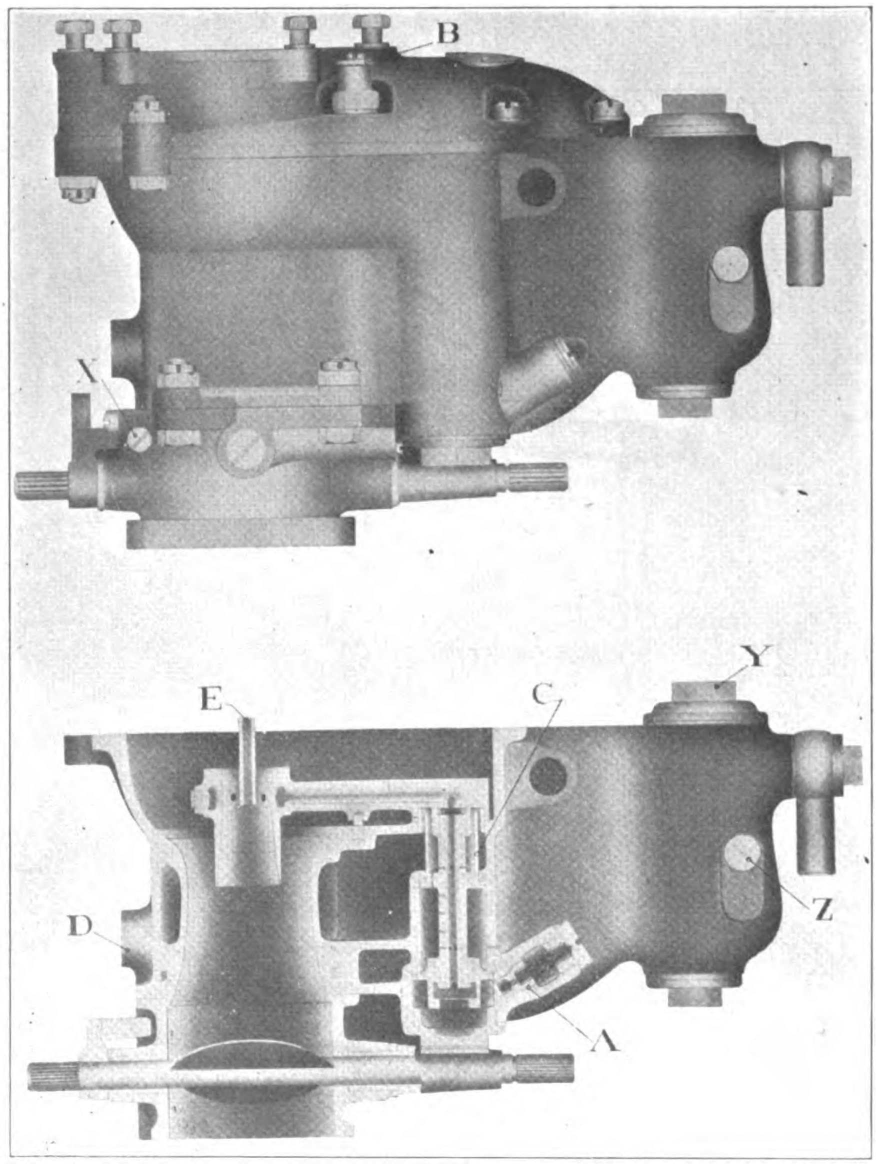

Fig. 1.—Stromberg NA-L5 double venturi inverted type carburetor.

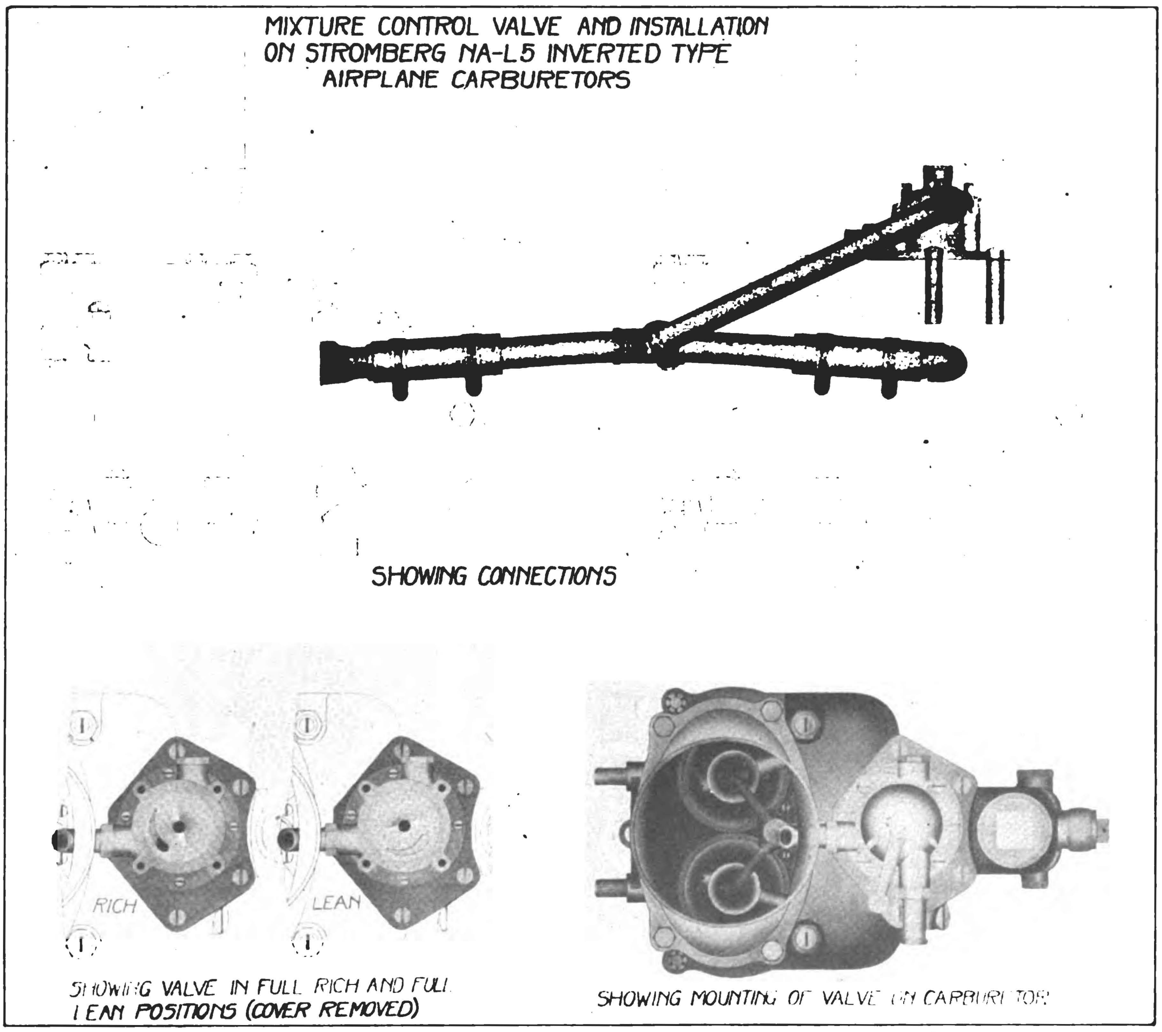
MIXTURE CONTROL VALVE AND INSTALLATION
ON STROMBERG NA-L5 INVERTED TYPE
AIRPLANE CARBURETORS
SHOWING CONNECTIONS
RICH
LEAN
SHOWING VALVE IN FULL RICH AND FULL
LEAN POSITIONS (COVER REMOVED)
SHOWING MOUNTING OF VALVE ON CARBURETOR

FIG. 2.

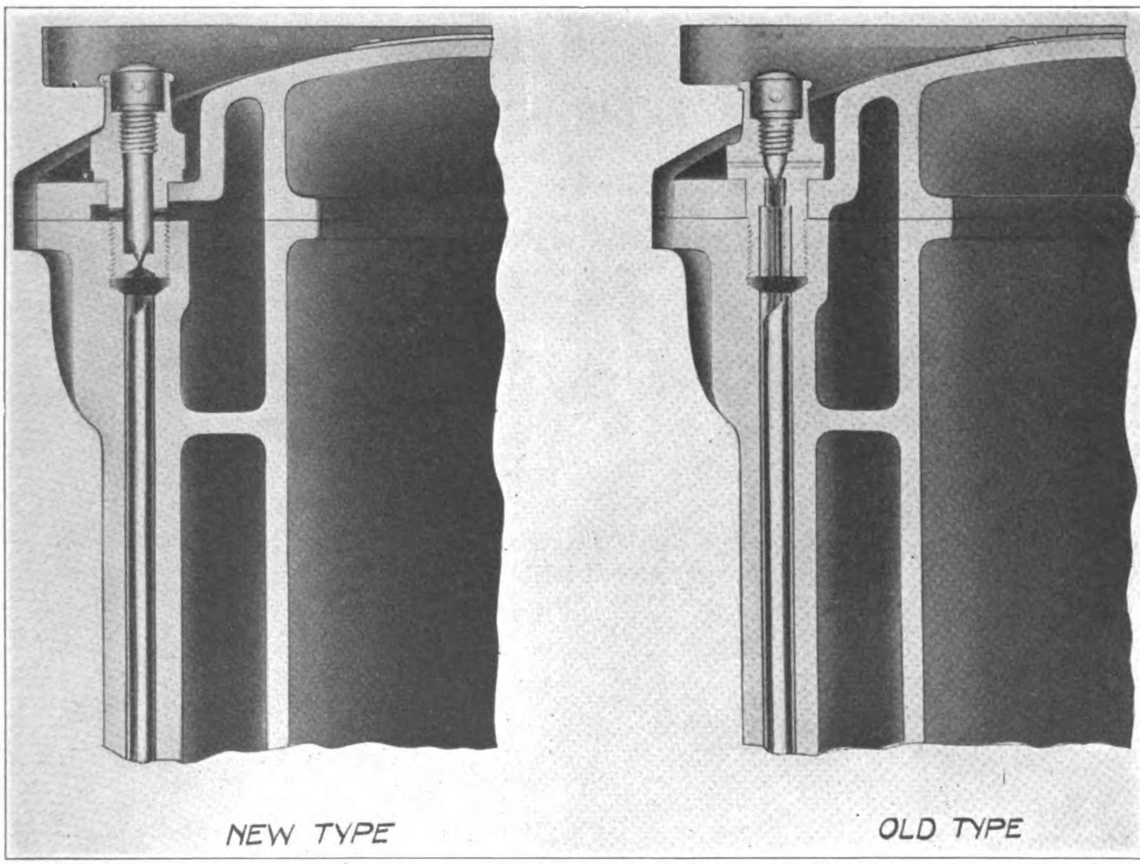

FIG. 3.—New and old type idling adjustment for Stromberg NA-L5 inverted type airplane carburetors.